lec 5

$$Z_{in} = Z_0 \frac{V_0^+ e^{j\beta l} + V_0^- e^{-j\beta l}}{V_0^+ e^{j\beta l} - V_0^- e^{-j\beta l}} \rightarrow 1$$

$$Z_{in} = Z_0 \frac{e^{j\beta l} + \frac{V_0^-}{V_0^+} e^{-j\beta l}}{e^{j\beta l} - \frac{V_0^-}{V_0^+} e^{-j\beta l}}$$

$$Z_{in} = Z_0 \frac{e^{j\beta l} + \Gamma e^{-j\beta l}}{e^{j\beta l} - \Gamma e^{-j\beta l}}$$

$$V_0^- = \Gamma V_0^+$$

$$\Gamma = \frac{V_0^-}{V_0^+}$$

$$\Gamma = \frac{Z_l - Z_0}{Z_l + Z_0}$$

$$Z_{in} = Z_0 \frac{e^{j\beta l} + \left(\frac{Z_l - Z_0}{Z_l + Z_0}\right) e^{-j\beta l}}{e^{j\beta l} - \left(\frac{Z_l - Z_0}{Z_l + Z_0}\right) e^{j\beta l}} \times (Z_l + Z_0)$$

$$Z_{in} = Z_0 \frac{(Z_l + Z_0) e^{j\beta l} + (Z_l - Z_0) e^{-j\beta l}}{(Z_l + Z_0) e^{j\beta l} - (Z_l - Z_0) e^{-j\beta l}} = Z_0 \frac{Z_l (e^{j\beta l} + e^{-j\beta l}) + Z_0 (e^{j\beta l} - e^{-j\beta l})}{Z_l (e^{j\beta l} - e^{-j\beta l}) + Z_0 (e^{j\beta l} + e^{-j\beta l})}$$

$$Z_{in} = Z_0 \frac{2 Z_l \cos\beta l + 2j Z_0 \sin\beta l}{2j Z_l \sin\beta l + 2 Z_0 \cos\beta l} = Z_0 \frac{Z_l \cos\beta l + j Z_0 \sin\beta l}{Z_0 \cos\beta l + j Z_l \sin\beta l}$$

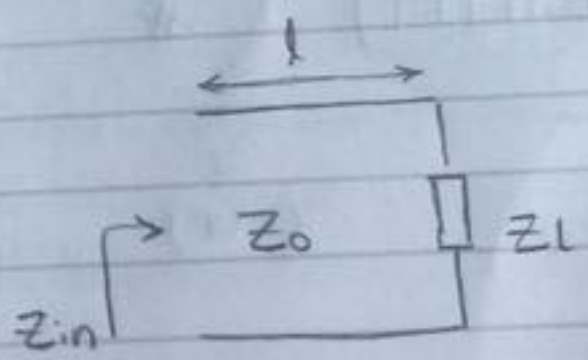
(cos βl) ده دايما

بس

$$Z_{in} = Z_0 \frac{Z_l + j Z_0 \tan\beta l}{Z_0 + j Z_l \tan\beta l} \quad \ast \rightarrow A$$

Z_{in} : is the input impedence of aloss less T.l terminated by load Z_l

$$\gamma = \underline{\alpha}_0 + j\beta$$



Special cases:

1) for $l = \lambda/2$ T.L. :

Sub in A → $\tan \beta l = \tan\left(\frac{2\pi}{\lambda} \cdot \frac{\lambda}{2}\right) = \tan(\pi) = 0$

$\therefore Z_{in} = Z_0 \frac{Z_l}{Z_0}$ → $\therefore Z_{in} = Z_l$ (pure real) if Z_l is pure real

↳ يكافئ مقاومة T.L.

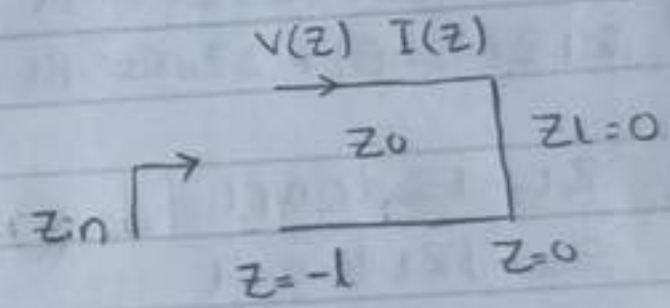
2) for $l = \lambda/4$ T.L. :

$\tan(\beta l) = \tan\left(\frac{2\pi}{\lambda} \cdot \frac{\lambda}{4}\right) = \tan\left(\frac{\pi}{2}\right) = \infty$

$\frac{\infty}{\infty}$ عشان لما أعوض هتطلع A عشان $\tan(\beta l)$ قسم المعادلة على

$Z_{in} = Z_0 \frac{\left(\frac{Z_l}{\tan \beta l}\right) + jZ_0}{\left(\frac{Z_0}{\tan \beta l}\right) + jZ_l} = Z_0 \frac{jZ_0}{jZ_l} = \frac{Z_0^2}{Z_l}$ (pure real) if Z_l is pure real

Case 1 : T.L. terminated by S.C :



$Z_L = 0$ Sub in A

$Z_{in} = Z_0 \frac{jZ_0 \tan \beta l}{Z_0}$

S.W.R = ∞

$Z_{in} = jZ_0 \tan(\beta l)$ #

(+ve) (-ve)

→ let $\tan(\beta l) = +1$ (مثلي)

$Z_{in} = jZ_0 = j\omega l$, $\omega l = Z_0$

$\therefore l = \frac{Z_0}{\omega_0}$ (ملف)

→ let $\tan(\beta l) = -1$

$Z_{in} = -jZ_0 = \frac{Z_0}{j} = \frac{1}{j\omega C}$, $Z_0 = \frac{1}{\omega C}$

$\therefore C = \frac{1}{\omega Z_0}$ (مكثف)

$V(z) = V_0^+ (e^{-j\beta z} + \Gamma e^{j\beta z})$

$I(z) = \frac{V_0^+}{Z_0} (e^{-j\beta z} - \Gamma e^{j\beta z})$

$Z_l = 0$ S.C $\longrightarrow$ $\Gamma = \frac{Z_l - Z_0}{Z_l + Z_0} = -1$

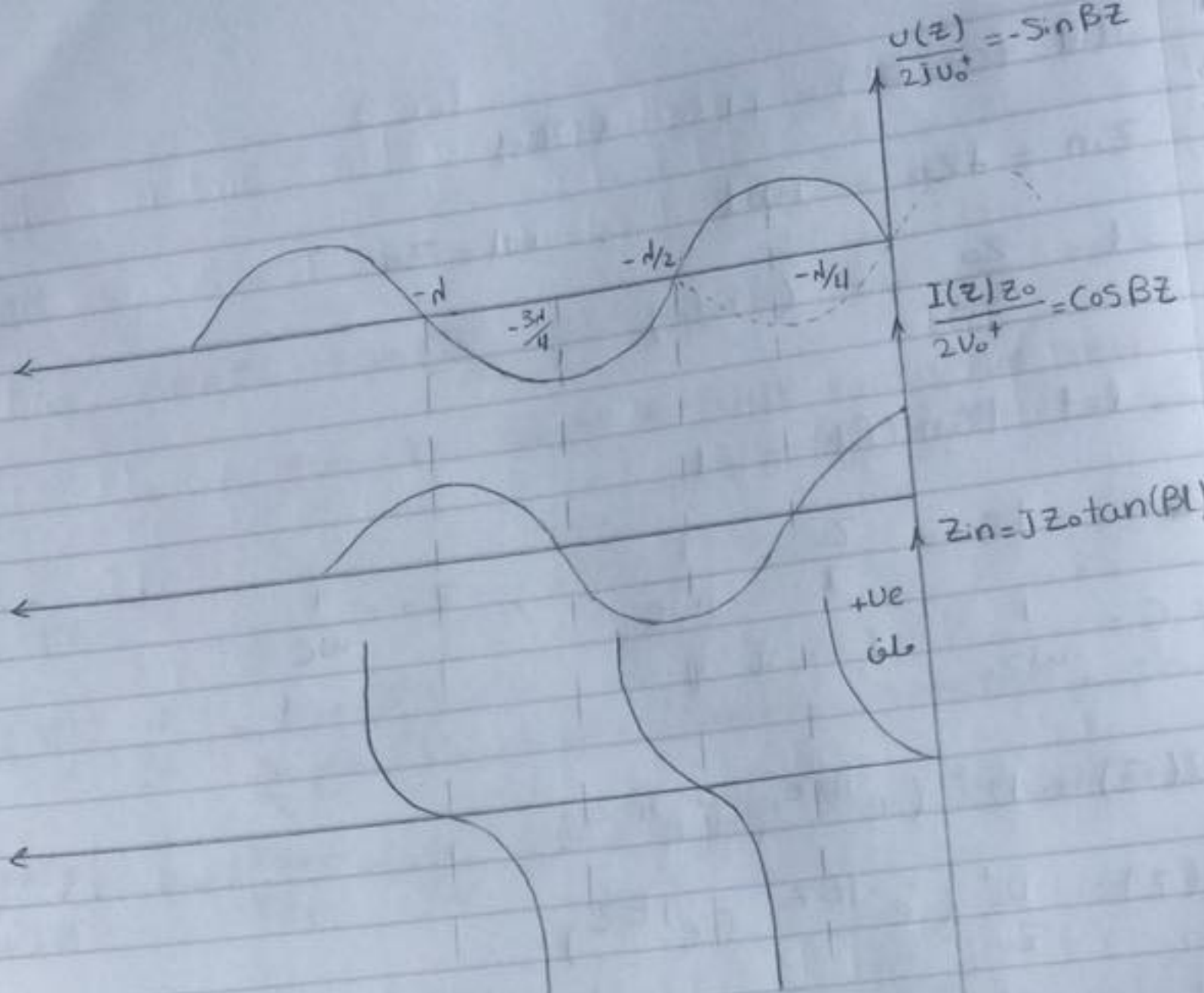
الاشارة السالبة معناها أن ال signal بترجع بـ phase shift = 180°

$V(z) = V_0^+ (e^{-j\beta z} - e^{j\beta z}) = -2j V_0^+ \sin \beta z$

بعوض بـ sin لان الجهد عند ال S.C بـ zero

$\therefore V(z) = -2j V_0^+ \sin \beta z$

$I(z) = \frac{V_0^+}{Z_0} (e^{-j\beta z} + e^{j\beta z}) = \frac{2V_0^+}{Z_0} \cos \beta z.$



Case 2: T.L terminated by open circuit $Z_L = \infty$

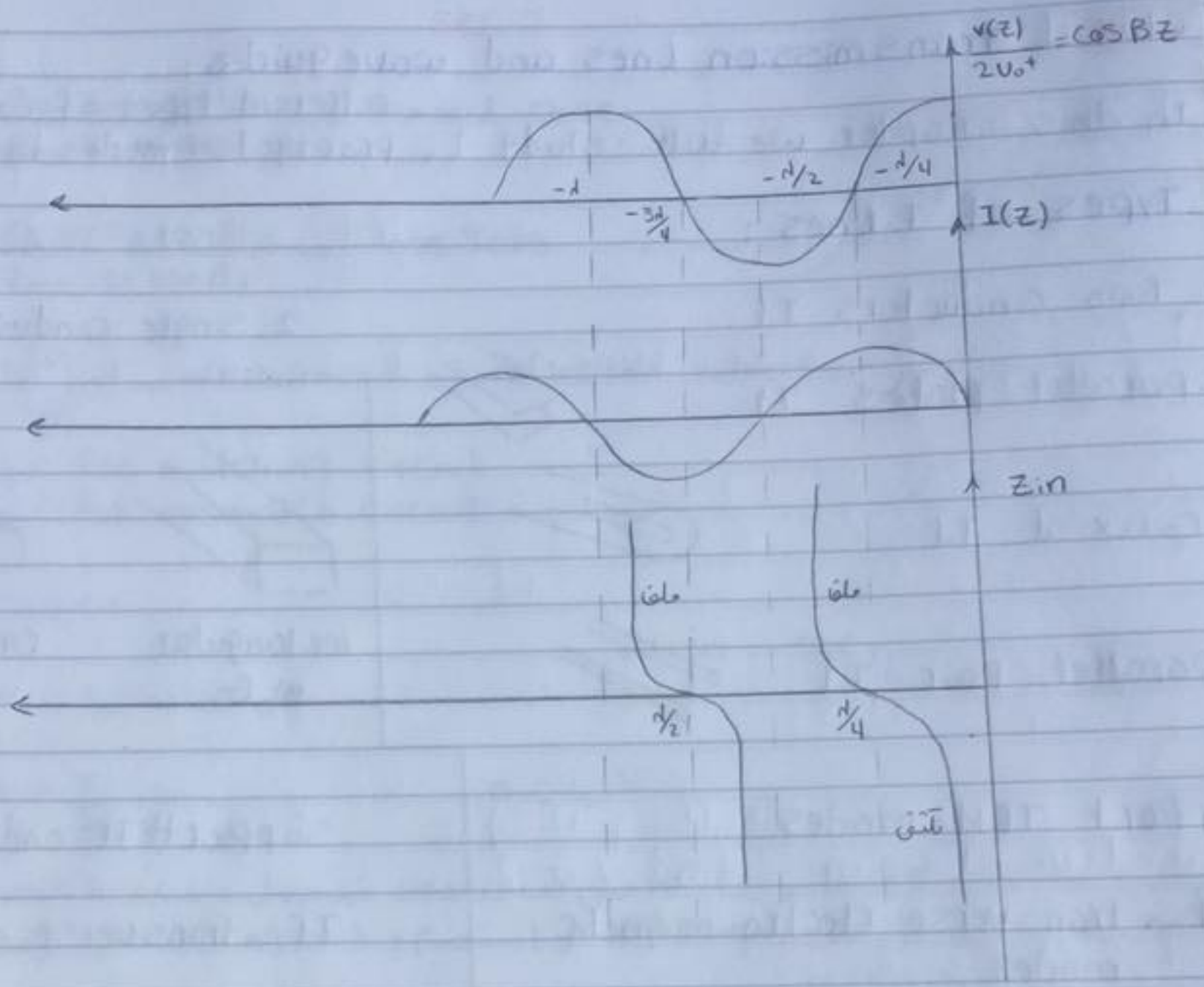
$$\Gamma = \frac{Z_l - Z_0}{Z_l + Z_0} = \frac{1 - \frac{Z_0}{Z_l}^{\to 0}}{1 + \frac{Z_0}{Z_l}^{\to 0}} = 1 \qquad SWR = \infty$$

لو بدلك اذا z صفر بدل $z = -l$

$$U(z) = U_0^+ (e^{-j\beta z} + e^{j\beta z}) = 2U_0^+ \cos\beta z$$

$$I(z) = \frac{U_0^+}{Z_0}(e^{-j\beta z} - e^{j\beta z}) = -2j\frac{U_0^+}{Z_0}\sin\beta z$$

$$Z_{in} = Z_0\frac{Z_l + jZ_0\tan\beta l}{Z_0 + jZ_l\tan\beta l} = Z_0\frac{1 + \frac{jZ_0}{Z_l}^{\to 0}\tan\beta l}{\frac{Z_0}{Z_l}^{\to 0} + j\tan\beta l} = \frac{Z_0}{j\tan\beta l} = -jZ_0\cot\beta l$$


V(z)/2V0+ = cos βz
-λ
-λ/2
-λ/4
-3λ/4
I(z)
Zin
ملف
ملف
λ/2
λ/4
تلتقي

Ch#2: Transmission lines and waveguides:

In this chapter we will study → different types of w.G
→ propagation modes in w.G

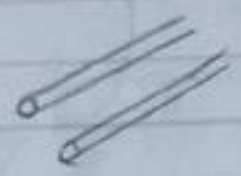
- Types of T. lines:

1- Two conductors T.L:

- Parallel plates T.L

- Coaxial T.L

- Parallel pair T.L

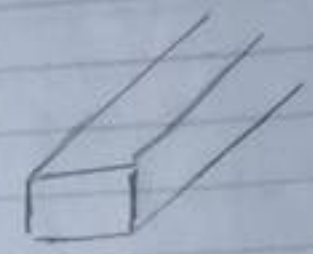


Support TEM modes

TEM → transverse Electro magnetic modes

+ TE + TM

2- Single conductor T.L:



rectangular w.G

circular w.G

Support TE and TM modes.

TE → transverse electric modes

TM → transverse Magnetic modes